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Use of mathematical optimization models to derive healthy and safe fish intake

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This study presents a method to model personalized food recommendations that requires the smallest possible diet change. The study is both methodological, describing the quadratic programming model used, and a case study on fish intake in Denmark.

Background. Recommended fish intake differs substantially from observed fish intake. In Denmark, around 15% of the population meets the Danish recommendation on fish intake. How much fish individuals eat varies greatly. There are so many different patterns of fish intake that the fish intake of the average population cannot reflect this.

Objective. We developed a method that may provide realistic and achievable personalized dietary recommendations based on an individual's body weight and current fish intake. The objective of the study was to propose specific fish intake levels for individuals that meet the recommendations for eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), and vitamin D without violating the tolerable intake recommendations for methyl mercury, dioxins, and polychlorinated biphenyls (dl-PCBs).

Methods. Two mathematical optimization models were developed that apply quadratic programming to model personalized recommended fish intake, fulfilling criteria on nutrients and contaminants, while simultaneously deviating as little as possible from observed individual intake. A recommended intake for eight fish species was generated for each individual in a group of 3,016 Danes (1,552 women and 1,464 men, ages 18-75), whose fish intakes and body weights were known from a national dietary survey.

Results. Individual, personal dietary recommendations were successfully modeled. Modeled fish intake levels were compared with observed fish intakes. For women, the average proposed increase in fish intake was 14 g/wk for lean fish and 63 g/wk for fatty fish; and for men these numbers were 12 g/wk and 55 g/wk, respectively.

Conclusions. Using fish intake as an example, we show how quadratic programming models may be used to advise individual consumers on the optimization of their diet, taking both benefits and risks into account. This approach has the potential to increase compliance with dietary guidelines by targeting the individual consumers and minimizing the need for large and eventually unrealistic behavior changes.